REMARKS

Claims 1-9 are present in the above-identified application. Claim 1 is an independent claim.

INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement is enclosed containing documents discovered when researching the Juday patent. The Examiner is requested to consider those documents and return a copy of the initialed Form PTO-1449.

DRAWINGS

Figure 10 has been objected to for not being designated "prior art". Applicants respectfully traverse that objection. Figure 10 is conventional art known only to Applicants, has not been previously disclosed, and thus is not in fact prior art. Accordingly, Applicants request that the objection be withdrawn.

CLAIM REJECTION UNDER 35 U.S.C. 103

Claims 1-9 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Applicants admitted prior art (Figure 10) in view of Juday, et al. (U.S. Patent No. 5,067,019, hereinafter referred to as Juday). Applicants respectfully traverse that rejection.

Applicants note at the outset that the disclosure with respect to Figure 10 is not in fact prior art but instead is a prior iteration of the present invention known only to

Applicants. Accordingly, for at least this reason, Applicants submit that the Office Action does not present a *prima facie* case of obviousness. Applicants respectfully request that the rejection be withdrawn.

SUMMARY OF THE PRESENT INVENTION

The present invention, in a preferred embodiment, is directed to an omniazimuthal visual system for use in systems such as surveillance cameras and mobile robots. Specifically, Applicants disclose an omniazimuthal visual system that includes an optical system which is capable of obtaining an image of 360° field of view and an image transformation section which transforms the round shape optical image obtained from the optical system into an image which is easier for a human to see, such as a panoramic image or a perspective image. In developing the omniazimuthal visual system, Applicants have made use of previously developed optical systems capable of obtaining an image of 360°. Among the optical systems used include a hyperboloidal mirror optical system (shown in detail in Figure 2), or a paraboloidal mirror optical system (shown in detail in Figure 9).

In developing the present image transformation processing device of the present preferred embodiment, Applicants first developed a software version of the image transformation system

(See Figure 10). The software version of the omniazimuthal visual system was unable to achieve real-time processing speed sufficient to serve as a practical device for use in surveillance cameras or mobile robots. In particular, when the image transformation processing was carried out by software, 20 or more steps were required in arithmetic processing for a single data transformation. Further, when software was used it was necessary to frequently repeat a step of reading out intermediate results from a register, and temporarily storing a calculation result again in that same register. Furthermore, in the case of a dynamic image with a great number of pixels, the software implementation could not catch up with the required processing speed. Thus, the quality of images obtained was significantly deteriorated.

The present preferred embodiment greatly improves on processing speed by implementing the software implementation in hardware. In a preferred embodiment of the present invention, a hardware implementation eliminates the need for storage of immediate results, implements specific image transformation functions in circuits which use only linear operations, and uses a look-up table for storing trigonometric functions.

An image transformation section in the present preferred embodiment includes an arithmetic logic circuit (element 111). The arithmetic/logic circuit includes at least one of a circuit

for panoramic transformation and a circuit for prospective transformation. Applicants have developed expressions for panoramic transformation and prospective transformation which can be computed using only linear operations (see Figures 4 and 5 and associated discussion in the specification on pages 23-33). From these expressions, Applicants have developed the logic circuits for performing the panoramic transformation and prospective transformation (see Figures 6 through 8). Based on the circuit for panoramic transformation, by changing only one parameter, the same circuit can alternatively be used to perform a pan function based on image data from an image section. Similarly, the circuit for prospective transformation can alternatively be used for pan/tilt, zoom-in/zoom-out computations by changing only one parameter. Further, Applicants have removed the need for an additional buffer memory by having the coordinate transformation operation performed after any one of a zoom-in/zoom-out processing or pan/tilt processing (see page 22). In summary, with the use of an optical system that provides image data for a 360° field of view from the prospective of a focal point per pixel and simple logic circuits for performing prospective transformation which can alternatively be used to process zoom-in/zoom-out and pan/tilt, Applicants have produced an omniazimuthal visual system that can perform at high

enough processing speed for use in surveillance and mobile robot systems.

JUDAY

Juday is directed to a programmable remapper for image processing, and in particular a remapper which accepts a real-time video image in the form of a matrix of pixel elements and remaps the image according to a selectable one of a plurality of mapping functions to create an output matrix of pixels. The image processing system can handle any number of transformation functions in real-time so that the input image may be spatially remapped prior to presenting them to an optical correlator or prior to displaying them on an image display device to aid people with low vision problems. To handle the remapping in real-time for any number of different remapping transformations, the programmable remapper (item 10, shown in Figure 1) comprises two parallel processors, each comprising look-up tables, a collective processor (item 20) which maps multiple input pixels into a single output pixel and an interpolative processor (item 22) which performs an interpolation among pixels in an input image. The system further consists of a conventional video camera which produces a matrix of pixels of an x-y Cartesian matrix. The mapping functions, in turn, produce an output Cartesian matrix.

The collective processor (see Figure 3) includes look-up tables for storing addresses of pixel data (see column 7, ll 44-51) and for weighting factors (see column 7, l 61, to column 8, l 6). The Collective Processor applies the weighting factors to input pixels to produce an output pixel. This is done with a multiplier and adder (multiplier 30, adder 42). In Interpolative Processor (see Figure 4), weights for each pixel are stored in look-up tables (item 56) and pixel values are supplied to and from a buffer memory (item 50). The Interpolative Processor performs an interpolation function using the weighted factor (equation 3 in column 9). It is processed with a multiplier and adder (multiplier 68, adder 72).

In an alternative embodiment, the Programmable Remapper can be implemented in hardware to perform image panning. A Collective Processor for input image panning, for example, is disclosed (see Figure 10A). Image Panning is accomplished by setting pan values into x-y offset registers. The registers effectively apply an offset to the look-up tables for any particular transformation stored causing different factors to be read out of different input image pixels. The hardware implementation of an Interpolative Processor for input image panning also makes use of an x offset register and a y offset register. Effectively, the contents of frame buffers are changed due to the offset address when loading pixels. Similarly, the

alternative use of the hardware implementations for output image panning is described. Thus, Juday discloses a hardware implementation having an image panning feature that provides high speed, high resolution pan/tilt function that is operator controllable.

DIFFERENCES OVER JUDAY

The present claimed invention is directed to an omniazimuthal visual system comprising an optical system capable of obtaining an image of 360° view field area as well as an image transformation section for performing coordinate transformation on data obtained from the optical system. An image transformation section includes at least one buffer memory, an arithmetic/logic circuit, a look-up table, and a CPU. A look-up table is for a trigonometric function and is for use with the arithmetic/logic circuit. Applicants submit that Juday fails to teach or suggest at least an image transformation section that includes an arithmetic/logic circuit for performing coordinate transformation based on image data obtained from an image of 360° view field area as well as a look-up table of a trigonometric function for use in the arithmetic/logic circuit, as in present claim 1.

As mentioned above, Juday is directed to a programmable remapper that works with a conventional video camera. It is not directed to an omniazimuthal visual system including an optical

system capable of obtaining an image of 360° view field area and a remapper for image processing over that view field area. In any case, the Office Action alleges that the factor look-up table 36 or the address look-up table 34a disclosed in Juday constitutes the claimed look-up table of a trigonometric function. However, the factor look-up table only produces weighting factors and the address look-up table is for associating addresses with pixels. Neither of those look-up tables is of a trigonometric function. Furthermore, the Office Action alleges that the multipliers 30 and 68, and the adders 42 and 72 constitute an arithmetic/logic circuit for performing coordinate transformation. However, Juday is directed to a general purpose programmable remapper that works with input preferably from a conventional video camera. The transformations that the programmable remapper performs are from one Cartesian matrix to another Cartesian matrix. Juday does not disclose, for the sake of argument, performing coordinate transformation based on circular image data from an optical field of view of 360°. Finally, as noted above, Figure 10 in the present specification is not directed to prior art but rather directed to a previous iteration of the present embodiment known only to the Applicants. Accordingly, at least for these reasons, Juday, either alone or in combination with the references disclosed in

the present specification, fails to teach all of the elements of claim 1.

With respect to claim 6, that claim is directed to an alternative embodiment, shown for example in Figure 9 along with the entire visual system, shown for example in Figure 1. It is not directed to the hyperboloidal mirror optical structure as alleged in the Office Action. Accordingly, the subject matter of claim 6 is not taught or suggested by JP 6-295333 relied on in the Office Action.

Furthermore, claim 3 is directed to first performing zoom-in or zoom-out processing or pan/tilt processing, then performing one of panoramic or prospective processing. As disclosed on page 22 of the present specification, Applicants have found that by following such a procedure, transformation can be carried out without a need for an additional buffer memory. Juday, nor any of the other references disclosed in the present specification, teach or suggest this procedure as part of image transformation. Accordingly, at least for this additional reason, Juday, either alone or in combination with the references disclosed in the present specification, fails to teach or suggest all elements of claim 3.

With respect to the remaining dependent claims, at least for the same reasons as above for claim 1, Juday fails to teach or suggest all of the claimed elements of those claims as well.

Accordingly, Applicants respectfully request that the rejection under 35 U.S.C. 103 be withdrawn.

NEW CLAIMS

Claims 10 and 11 have been added to further recite features with respect to the panoramic transformation circuit and prospective transformation circuit of the present invention. The claims are supported by disclosure on pages 23-33 of the present specification. These claims clearly distinguish over Juday, which, for example, requires alternative circuitry for pan operations (illustrated in Figures 10a and 10b, for example).

CONCLUSION

In view of the above remarks, reconsideration of the rejections and allowance of each of claims 1-11 in connection with the above identified application is earnestly solicited.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Robert W. Downs (Reg. No. 48,222) at the telephone number of the undersigned below, to ***arrange for an interview*** in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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